Forest Insect Laboratory
Coeur d'Alene, Idaho

February 12, 1951

To: J. A. Beal, In Charge, Forest Insect Investigations

From: James C. Evenden, P. O. Box 630, Coeur d'Alene, Idaho

Subject: Penetrating Spray - Douglas Fir Beetle

A copy of Mr. Gibson's report "Experiments to Test the Effectiveness of Penetrating Sprays Against the Douglas Fir Beetle" is enclosed. Mr. Gibson shows some conclusive information as to the effectiveness of penetrating sprays, but we do not consider the project as being complete. Just what repetition and new work is needed will be decided at our staff conferences on research. We will hold the first of these on February 16.

Would be glad to have your comments.

cc: Furniss
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by
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Entomologist

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EXPERIMENTS TO TEST THE EFFECTIVENESS OF PENETRATING SPRAYS AGAINST THE DOUGLAS FIR BEETLE

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Control of the mountain pine beetle in lodgepole and western white pine with penetrating sprays has been established practice for a number of years. The comparatively thin bark of these two tree species has proved no effective barrier to the penetration of the oil-base sprays developed for control of the cambium-feeding mountain pine beetle broods. Where infested lengths are comparatively short, spraying standing lodgepole pine to control infesting bark beetle broods has been successfully demonstrated on large projects in the last few years. However, control of the Douglas fir beetle in Douglas fir by means of penetrating sprays seemed to impose more serious problems. Chief of these was the much thicker bark. Trees as small as 12 inches in diameter breast high will usually have a bark thickness of at least 1½ inches for many feet up from the base. Bark up to three inches thick is not unusual on the larger trees in the Inland Empire. Furthermore, the bark tends to form increasingly large plates with increase in tree diameter. Penetration of such bark by enough spray to kill the infesting brood beneath, seemed decidedly unlikely. Even the presence of numerous deep furrows, reaching to within as little as one-quarter inch of the sapwood, was considered of little value because previous experience with lodgepole and western white pine had shown there was little if any lateral distribution of the oil-base sprays. The corky nature of the bark seemed to be just another difficulty to be considered.

In spite of the discouraging outlook, the need for a cheaper control method was so urgent it was decided to initiate some exploratory tests with penetrating sprays in 1949. From them it was hoped either some promising leads, or elimination of penetrating sprays as a possible control measure, might be obtained.

In outlining the tests to be conducted it was decided to use a 1 to 3 concentration of orthodichlorobenzene in Diesel oil, as well as the 1 to 5 concentration in general use on control projects. The high concentration formula was a concession to the severe conditions previously discussed. Should even small quantities of the stronger formula penetrate the bark, the spray might give acceptable control. Other chemicals which had given good control against the mountain pine beetle were also to be used in the hope that one of them might prove effective if orthodichlorobenzene did not.

Recognizing that spraying trees standing probably imposed the most difficult test of penetrating spray effectiveness, a number of infested trees were to be so treated. Logs were also to be sprayed.

Trees recently attacked offer greater resistance to spray penetration than those attacked some time prior to treating. Both types were to be included insofar as available material and time would permit.

In the outline following are the tests initiated in 1949.

Outline of Experimental Control Against
The Douglas Fir Beetle in Douglas Fir
1949

Lethal Material	Amount	Amount of Diesel Oil	Douglas Fir Material Treated
Orthodichlorobenzene	1-part	5 parts	Basal 5' of standing trees
"	1-part	3 parts	" " " " "
Dichloroethyl ether	1-part	5 parts	" " " " "
Trichlorobenzene	1-part	5 parts	" " " " "
Orthodichlorobenzene	1-part	5 parts	Logs
"	1-part	3 parts	"
Trichlorobenzene	1-part	5 parts	"
Orthodichlorobenzene	1-part	5 parts	Standing trees to 15-20 feet

To obtain the more representative data afforded by treating a large number of trees, only the base of twenty were sprayed to about five feet. To safeguard conclusions, however, a smaller number but still enough for an adequate sample, were treated to from 15 to 20 feet. In the spraying of infested logs a duplication of the technique for treating mountain-pine-beetle infested western white pine was employed. This consists of spraying the upper side of the log, then the log is turned until an unsprayed portion adjoining that previously sprayed, is upper-most. This second sector is sprayed, and the procedure continued until the entire circumference is treated. The foregoing

tests were conducted and preliminary examinations made in late 1949. Supplementing the 1949 examination with a final one in the early summer of 1950, confirmed the excellent control secured. However, need for data from similar tests for a second year to safeguard any recommendations that might be made, resulted in more experimentation in 1950. In this report the tests of 1949, results of the preliminary and final examination of them, tests of 1950 and preliminary results of this second set, are recorded and discussed.

In treating this Douglas-fir-beetle-infested material, spray was applied until the bark surface glistened with the accumulated spray. The writer's impression that the bark was absorbing a surprisingly large amount of spray was substantiated by subsequent measurement of bark surface coverage per gallon of spray. Application of the spray was by means of a 3 ½-gallon back-pack pressure pump.

Two areas about one mile apart on the north side of Pinkham Creek, a few miles east of the Rexford Ranger Station, were selected for the initial experiments in 1949. Infestation was sufficiently concentrated and so located as to facilitate the experimental program planned. The tests conducted in 1950 were also on Pinkham Creek, on its west side, but about 3 miles south of the two areas on which the preceding year's tests were conducted. This site was somewhat cooler both because of the east exposure and a slightly higher elevation.

In determining the effect of the various treatments on infesting broods it was soon noted that, with few exceptions, a detailed examination was unnecessary. In general, control had been so complete that verification was all that was necessary, which was usually done by removing at least a square foot of bark surface and noting the brood status beneath it. Furthermore, it was found unnecessary to examine the large amount of material treated in some of the tests because of the uniform results.

The tests and results are condensed in Table I.

Table I

RESULTS OF TESTS TO CONTROL THE DOUGLAS FIR BEETLE IN DOUGLAS FIR WITH ORTHODICHLOROBENZENE - DIESEL OIL SPRAYS IN 1949-1950

Test No.	Spray Ratio(1)	When Treated	Bark Ex'm'd(2)	Results of Examinations Of Standing Trees
1	1 to 5	9-17-49	15.5	On 9-29-49 no surviving broods. Further check on 6-27-50 confirmed previous finding. Ten trees were treated to 5'.
2	1 to 5	9-22-50	2.5	On 11-2-50 4 trees treated to 5' had 89% mortality of infesting larvae.
3	1 to 3	9-17-49	10.0	On 9-29-49 7 trees treated to 5' had 100% kill of larvae to new adults. Further check on 6-27-50 confirmed previous observations.
4	1 to 5	9-29-49	36.0	On 6-29-50 5 trees treated to 15 to 20' showed 100% of the broods had been killed. Development had ranged from larvae to new adults when treated.
		Untreated	20.0	On 9-29-49 broods in 5 trees showed no abnormal mortality of larvae to new adults. Check of results 6-27-50 revealed medium to high emergence had occurred.

(1) Lethal agent to Diesel Oil
(2) Square feet

Table I Cont.

Test No.	Spray Ratio(1)	When Treated	Bark Ex'm'd(2)	Results of Examinations of Logs
5	1 to 5	9-20-49	15.2	On 9-29-49 7 logs revealed no surviving broods. Further check on 6-28-50 revealed no broods had developed to emerge.
6	1 to 5	9-22-50	1.75	On 11-2-50 7 logs revealed no surviving broods.
7	1 to 3	9-20-49	12.8	On 9-29-49 7 logs revealed no survivors. Further check on 6-27-50 confirmed previous observations.
		Untreated	13.6	On 9-29-49 4 logs revealed no brood mortality. On 6-28-50 a further check revealed emergence had been light but uniform from these logs.
		Untreated	1.0	On 11-2-50 1 log revealed no abnormal mortality had occurred and broods were numerous.

(1) Lethal agent to Diesel Oil
(2) Square feet

Table I (Cont'd)

RESULTS OF TESTS TO CONTROL THE DOUGLAS FIR BEETLE IN STANDING DOUGLAS FIR WITH PENETRATING SPRAYS IN 1949-50

Test No.	Spray Ratio(1)	When Treated	Bark Ex'm'd(2)	Results of Examinations of Trees Treated With
				Trichlorobenzene-Diesel Oil
8	1 to 5	9-19-49	10.5	On 9 trees treated to 5 feet and examined 6-28-50 no emergence had occurred from the treated portion but had been heavy above that area.
9	1 to 5	9-20-49	8.0	On 9-29-49 2 trees treated to height of 20' revealed 100% kill of larval to new adult stages. Further check on 6-28-50 confirmed previous observations.
		Untreated	8.0	No abnormal mortality noted 9-29-49 on 5 trees and observation on 6-28-50 revealed medium emergence.
				Dichlorethyl ether -Diesel Oil
10	1 to 5	9-19-49	7.25	On 5 trees treated to 5 feet and examined 6-27-50 all broods had been killed, apparently the previous season shortly after treating.
		Untreated		In addition to the general check trees in the group, which had shown no abnormal mortality when examined the previous September, one tree was felled and examined above the treated portion in June of 1950. No emergence had occurred in the treated portion but it had been medium above that to the height of 30 feet.

(1) Lethal agent to Diesel Oil
(2) Square feet

A further check on spray effectiveness was obtained from two treated trees felled when examined. Both had been treated to five feet, one with the 1 to 3 orthene-Diesel oil mixture and the other with the 1 to 5 dichloroethyl ether-Diesel oil spray. The examination was not made until after insects had emerged. Spray effectiveness thus had to be measured by the presence or absence of emergence holes. Data from the two trees is shown in the succeeding tabulation, Table II.

Table II

Data from Two Douglas Fir Sprayed in September 1949 and Examined in Late June of 1950

Height at Which Samples Were Examined(1)

	4 ft.	10 ft.	20 ft.	30 ft.	40 ft.
Tree 1	None(2)	16	13	5	1
Tree 2	None(3)	22	15	18	Not sampled

(1) Samples 1 sq. ft. unless otherwise noted.
(2) Sample 2 sq. ft.
(3) Sample 1.5 sq. ft.

It has been found that more than one emerging new adult may use the same emergence hole. For that reason the preceding data may be considered conservative estimates of the number of emerging beetles.

Bark thicknesses ranging from 1/4 to 3 inches for the materials used in the tests, has been omitted from Table I. Diameters, which ranged from 8 to 23 inches have likewise been left out. Neither seems to have affected results.

Rapid control action of the sprays was an outstanding result. In spite of the comparative lateness of the season at the time the tests were initiated, in a lapse of but nine days, 100 percent control was obtained of bark beetle broods. Only occassional parent adults were alive and even they had been killed prior to the check examinations made the following June.

When examinations were made a short time after treating, larvae of all sizes, pupae, new adults and all but a few of the parent adults, were dead. Only dried up or badly deteriorated specimens of immature stages and dead adults were observed under treated bark late the following June. Emergence of new adults had occurred from untreated material, as indicated by emergence holes.

The thick bark proved highly absorbent of the spray. This reduced the average coverage per gallon of spray to only 35 square feet.

Duplication of Test #1 in the fall of 1950 revealed survivors under the thick bark at the base of one of the four treated trees, when they were examined later in the season. However, past experience with these sprays indicates we may expect complete control after a few hot days in late spring. Regardless of these survivors, control with the formula used in Test #1 can be recommended for control of the Douglas fir beetle in Douglas fir on either standing trees or logs.

Stronger concentrations of orthodichlorobenzene in Diesel oil were tested as part of the exploratory program. After the excellent results with the 1 to 5 mixture similar effectiveness could be expected and was noted with the 1 to 3 mixtures. As the 1 to 3 formula has no advantage over the 1 to 5 mixture, it should not be used.

Trichlorobenzene in Diesel oil has given satisfactory control of the mountain pine beetle in lodgepole pine. Similar effectiveness was noted in the exploratory tests against the Douglas fir beetle. Complete control was secured of bark beetle brood in standing trees, which is considered to offer the most adverse conditions. However, there is not the data available from two years of tests which is preferred before recommending a formula for control.

Another chemical which gave excellent control against the mountain pine beetle was dichlorcethyl ether. It too proved equally effective against the Douglas fir beetle in the one test for which we have data.

Trichlorobenzene, while as cheap as orthodichlorobenzene, has one quality making it somewhat less acceptable. It tends to form crystals more readily at cool temperatures. Heat, however, readily dissolves the crystals that may form in both orthodichlorobenzene and trichlorobenzene spray mixtures. Dichloroethyl ether does not have this somewhat detrimental property.

The unusually rapid control obtained with all spray formulae tested is considered an indication that weaker concentrations would be equally effective but probably require more time. Tests of weaker concentrations are suggested for both oil-base sprays and the ethylene dibromide emulsions. Costs per gallon of spray could be lowered appreciably by using a smaller percent of lethal agent.

One of the hopes of those interested in control with penetrating sprays was to develop a water-soluble spray or emulsion that would be effective against bark beetles. Such a spray would greatly reduce costs of

treating in remote areas where transportation of large quantities of oil for the oil-base sprays is an important cost item. Eliminating long transport of as much as 80 percent of the bulk of the sprays would decidedly reduce overall project costs. An approach to such an ideal seems to be developing in the use of ethylene dibromide emulsion. The few tests to date have given highly encouraging results and further tests should be conducted in 1951 duplicating those already made, and inaugurating others.

In 1950 tests were conducted with four formulae containing ethylene dibromide. In each case this chemical was mixed with fuel oil and an emulsifier and then with water to form an emulsion. Ethylene dibromide comprised about 5 percent of the total weight of two of the emulsions, about 2½ percent of a third and about 6⅓ percent of a fourth. The four tests were made on September 14 and 21 and a preliminary examination made on November 4 of two of the tests. Of the 28 logs and 15 trees treated 14 logs and 2 trees of two tests containing 5 percent ethylene dibromide were examined. Freezing temperatures and frozen cambium, from which the insects were taken, made it necessary to warm all insects for a considerable period before it could be determined if they were dead or alive. This time-consuming operation limited the number and extent of examinations. However, from the data obtained, it was found that results were highly encouraging. Final conclusions on results of these tests will not be available until the late spring of 1951 but the data that has been obtained indicates even weaker emulsions of ethylene dibromide may prove effective. They should and will be tested.

CONCLUSIONS

Results of tests begun in 1949 were a decided surprise because the conditions expected to prove so difficult to overcome were not found to be serious obstacles. Orthodichlorobenzene as the lethal agent in a Diesel oil carrier has proved just as effective in control of the Douglas fir beetle in Douglas fir as it has against the mountain pine beetle in lodgepole and western white pine. On the basis of tests conducted for two years a 5 to 1 mixture of Diesel oil to orthodichlorobenzene can be recommended. On a control project it would be found that a larger quantity of penetrating spray will be needed for control of the Douglas fir beetle than with lodgepole or western white pine due to the thicker and possibly more absorbent nature of Douglas fir bark.